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**25 YEAR RE-REVIEW**

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SOARD RADAR - AN/APQ-93

Review of Program since July 19, 1962

November 30, 1962

By

Westinghouse Electric Corporation

Air Arm Division

Baltimore 3, Maryland

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## PROGRAM FOR SOARD AN/APQ-93

### 1. CONTINUED DEVELOPMENT

- A. RESONANT RING IMPROVEMENT
- B. ANTENNA IMPROVEMENT
- C. RECORDER SPOT SIZE REDUCTION STUDY

### 2. RADAR MODIFICATION

- A. TRANSMITTER, CROSSED-FIELD AMPLIFIER
- B. IMPROVED MOTION COMPENSATION SYSTEM
- C. RECORDER

LENS OPTICS REPLACING FIBER OPTICS  
AUTOMATIC FILM SPEED CONTROL

- 3. DESIGN EVALUATION
- 4. ENVIRONMENTAL TEST
- 5. FLIGHT TEST
- 6. ACCESSORIES
- 7. INSTALLATION

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~~SECRET~~RESONANT RING IMPROVEMENT

	<u>GOAL</u>	<u>MEASURED</u>
1. ORIGINAL UNIT	0.5-1.0 MEG W. 10 NANOSEC. 20-40 W. AVERAGE.	0.23 MEG W. 10 NANOSEC. 9.2 W. AVERAGE.
2 LIMITING FACTORS	DRIVING POWER LOSSES IN RING	
3 IMPROVEMENTS	RING LENGTH INCREASED TUNING SHORTS IMPROVED	0.14 MEG W. 20 NANOSEC. 12.3 W. AVERAGE.
4 FURTHER IMPROVEMENTS	INCREASE RING LENGTH (FOLD) INCREASE DRIVE POWER	0.40 MEG W. 30 NANOSEC. 48 W. AVERAGE.

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## ANTENNA IMPROVEMENT

I. SIGNIFICANT FACTORS - HIGH TEMP. DESIGN 550° F  
-GAIN

A SPECIAL TECHNIQUES FOR HIGH TEMP - STAINLESS STEEL BEAM  
-ELECTRO-DEPOSITED NICKEL ELEMENTS  
-FIBRE GLASS-RESIN PRESSURE COVERS  
-HIGH TEMP CEMENT

## B. RESULTING UNIT HAD EXCESSIVE LOSSES

MAX. THEO. GAIN	38.9db
CALCUL. LOSSES	-7.4
PREDICTED GAIN	31.5db
MEASURED GAIN	29.5db

## C IMPROVEMENTS

MANIFOLD PHASE CORRECTION	.5db
HIGH PRESSURE ADHESION	1.5db
PREDICTED IMPROVED GAIN	<u>— 2.0</u> 31.5db

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## CFA TRANSMITTER SUMMARY

### 1. SIGNIFICANT FACTORS

- a. POWER OUTPUT ..... 1-2 MEGAWATT
- b. STABILITY ..... PULSE TO PULSE PHASE STABILITY  $< 5^\circ$
- c. PULSE WIDTH ..... 30 NANOSEC.

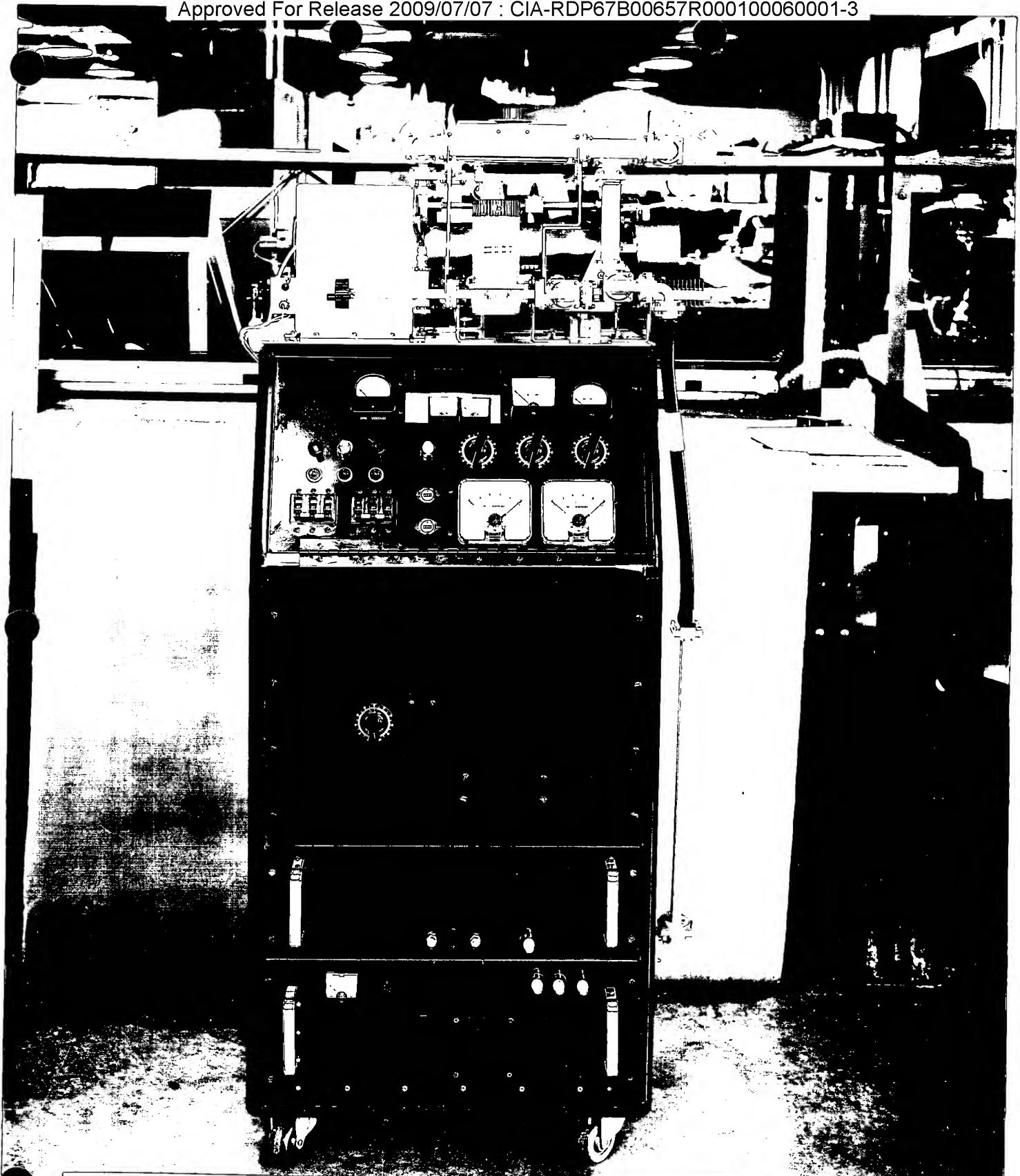
### 2 SPECIAL TECHNIQUES

- a. CROSS-FIELD AMPLIFIER DEVELOPMENT
- b. MATCH CHARACTERISTICS OF POWER SUPPLIES, MODULATORS, AND RF AMPLIFIERS
- c. DARLINGTON LINE MODULATOR FOR CFA AND GRID PULSED TWT FOR INTERMEDIATE AMPLIFIER
- d. MINIMUM WEIGHT DESIGN BY USING SF<sub>6</sub> INSTEAD OF AIR FOR HIGHER DIELECTRIC STRENGTH AND IMPROVED COMPONENT COOLING EFFICIENCY

### 3 PROGRAM

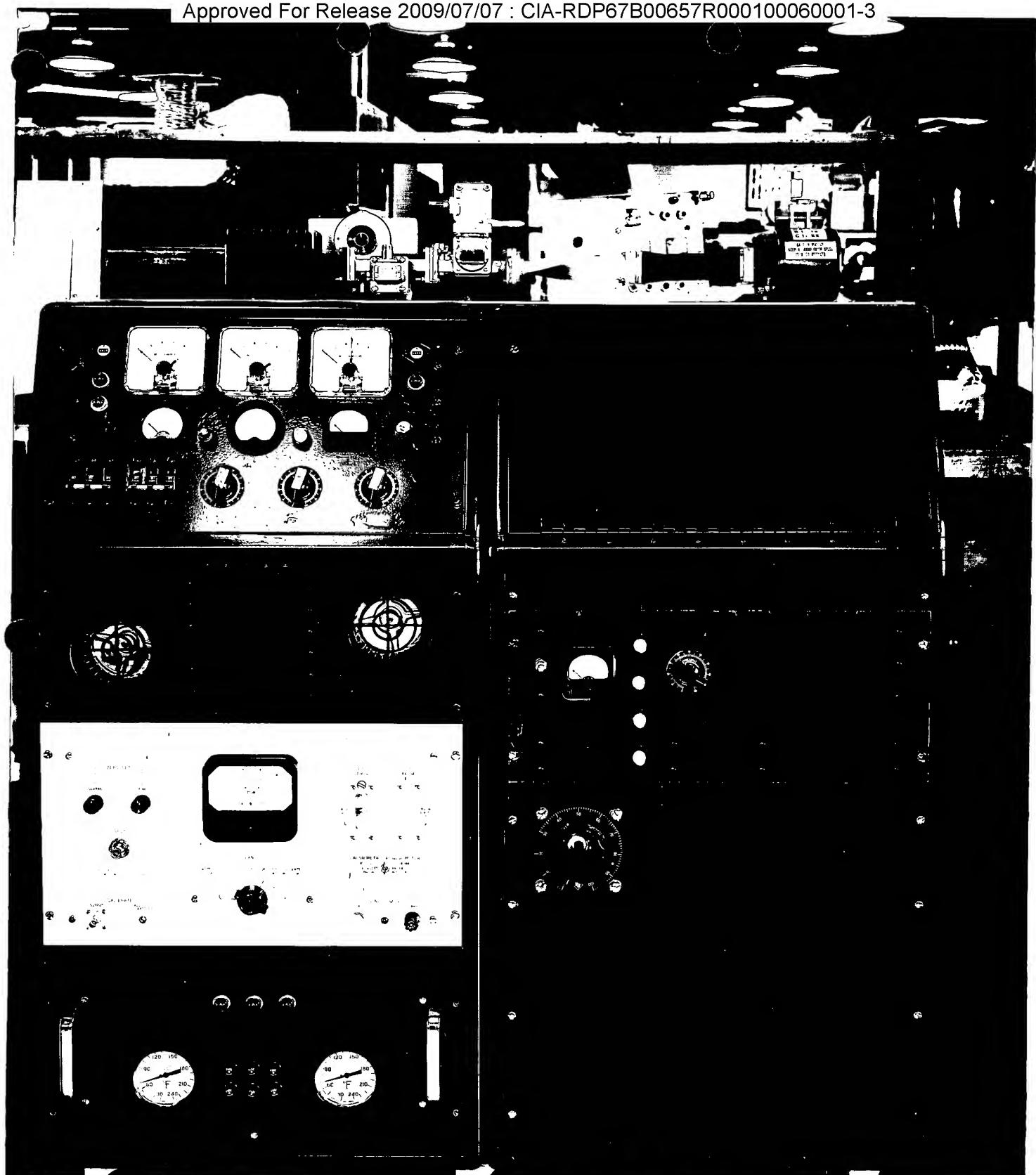
- a. BUILT AND TESTED LABORATORY BREADBOARD MODULATOR
- b. SFD FOR CFA TUBE DEVELOPMENT (1<sup>st</sup> TUBE DEL. 12-17-62)
- c. FLYABLE BREADBOARD 1-15-63
- d. 2 PROTOTYPES DELIVERED 6-1-63 AND 7-1-63 (TO BE DESIGN IMPROVEMENTS OF FLYABLE BREADBOARD)

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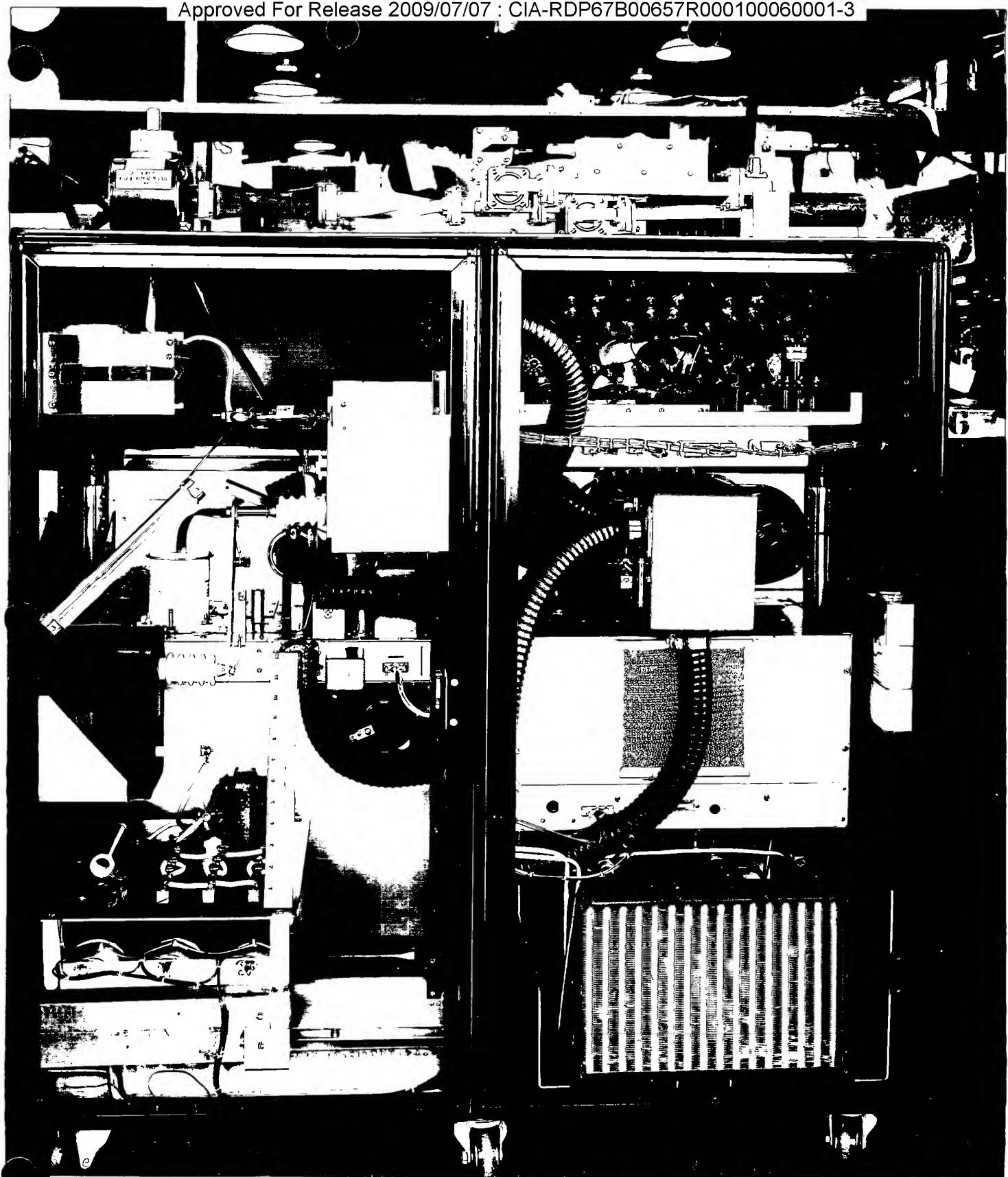


BREADBOARD TRANSMITTER, INTERMEDIATE AMPLIFIER, Modulator, Power Supply, Controls and Stalo.

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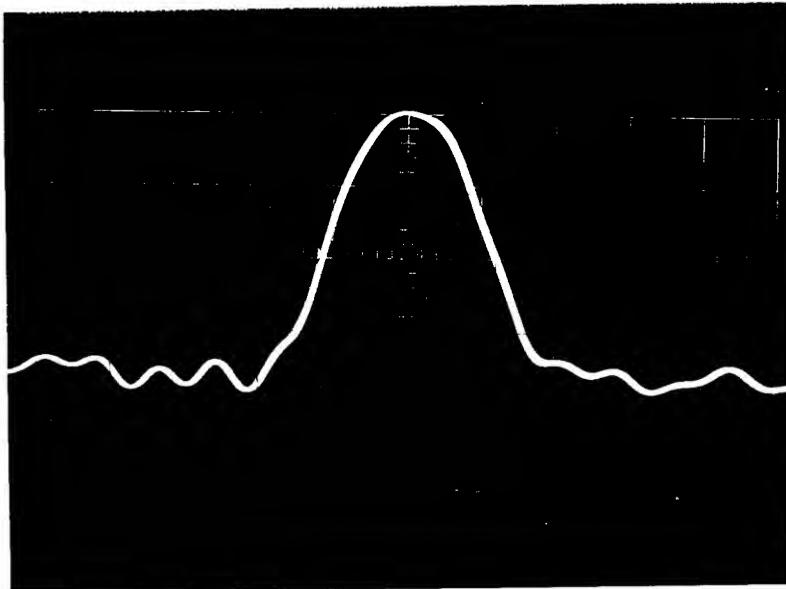


BREADBOARD TRANSMITTER, CFA MODULATOR - Modulator, HVPS, and controls with calorimeter for r-f power measurements and liquid to air heat exchanger. Shown with magnetron mounted for pulser testing.

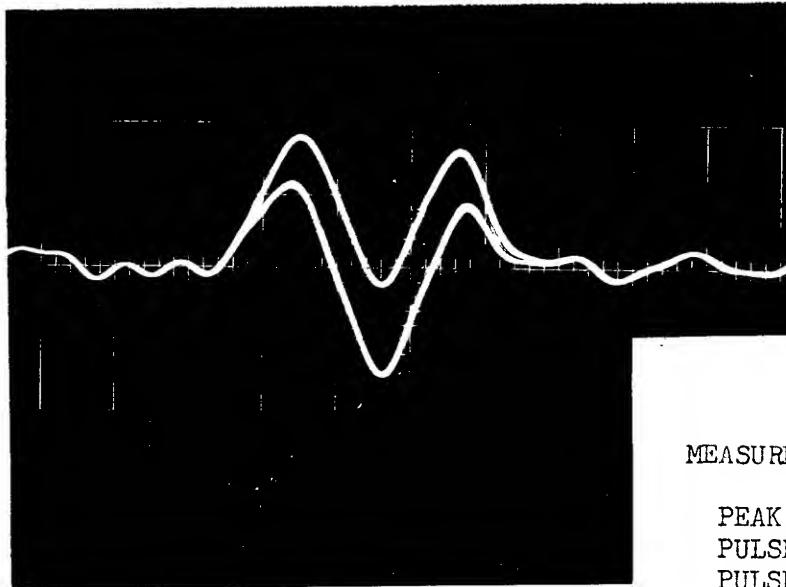


BREADBOARD TRANSMITTER, CFA MODULATOR - Rear view of cabinet showing components and accessories.

CROSS-FIELD AMPLIFIER WAVEFORMS



AMPLITUDE DETECTED R-F PULSE



PHASE DETECTED R-F PULSE  
(REFERENCE PHASE-SHIFTED BY  
20° TO SHOW PHASE JITTER  
SENSITIVITY OF 15°/CM)

CROSS-FIELD AMPLIFIER STATUS

MEASURED RESULTS:

PEAK POWER:	600 KW
PULSE WIDTH (-3 db)	40 NANOSEC
PULSE-TO-PULSE PHASE DEVIATION:	1.5° PK-PK
INTRAPULSE PHASE VARIATION:	+30°
GAIN (OVERDRIVEN CONDITION):	-16 db

(BOTH PICTURES ARE 1 SECOND EXPOSURE, COMPARABLE TO RADAR DWELL TIME)

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## ELEMENTS OF MOTION COMPENSATION

## ANGLE CORRECTION

ANTENNA PIVOTED AT AFT END

YAW STABILIZATION  $\pm 3^\circ$

CORRECTS FOR PITCH AND YAW ERRORS

TRANSIENT VOLTAGE CORRECTION

ACCEI / EBONETTEB - BOI | STABILIZED

INTEGRATION TO GIVE VELVET

## CONTROLS VARIABLE FREQUENCY GENERATOR

This block diagram illustrates a navigation system architecture. The system is enclosed in a large rectangular frame.

**Key Components and Connections:**

- ANTENNA:** A vertical bar at the top with a dashed line extending from its top right corner.
- TRANSMITTER:** A large rectangular block on the left side of the frame.
- RECEIVER:** A large rectangular block on the right side of the frame.
- INT. NAV. SYS.:** A rectangular block at the bottom center.
- VAR. FREQ. GEN.:** A rectangular block below the RECEIVER.
- INTEGRATOR:** A rectangular block to the right of the VAR. FREQ. GEN.
- ACCELEROMETER:** A small rectangular block with an arrow pointing to the INTEGRATOR.
- ACTUATOR:** A small rectangular block with an arrow pointing to the TRANSMITTER.
- ACTUATOR:** A small rectangular block with an arrow pointing to the RECEIVER.
- DRIFT CORRECTION:** A small rectangular block with an arrow pointing to the DFT block.
- DFT:** A small rectangular block below the DRIFT CORRECTION block.
- PITCH DRIVE:** A circular symbol with an arrow pointing to the INT. NAV. SYS. block.
- YAW DRIVE:** A circular symbol with an arrow pointing to the INT. NAV. SYS. block.
- ROLL:** An arrow pointing to the bottom right corner of the frame.

**Signal Flow:**

- From the INT. NAV. SYS. block, signals flow to the DFT block, then to the DRIFT CORRECTION block, and finally to the DFT block.
- From the DFT block, signals flow to the TRANSMITTER and to the RECEIVER.
- From the TRANSMITTER, a signal flows to the ACTUATOR (top).
- From the RECEIVER, a signal flows to the ACTUATOR (bottom).
- From the RECEIVER, a signal flows to the VAR. FREQ. GEN. block.
- From the VAR. FREQ. GEN. block, a signal flows to the INTEGRATOR.
- From the INTEGRATOR, a signal flows to the ACCELEROMETER.
- From the ACCELEROMETER, a signal flows back to the INTEGRATOR.
- From the INTEGRATOR, a signal flows to the ACTUATOR (right).

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**SECRET**DESIGN EVALUATION

## 1. PHASE STABILITY MEASUREMENTS

- A. FM DEVIATION OF ALL REFERENCE FREQUENCIES
- B. JITTER OF ALL TIMING PULSES: <4 NANOSEC
- C. SYNTHETIC HOLOGRAMS GENERATED-RECORDED- CORRELATED
- D. TRANSMITTER SIGNAL RADIATED TO 1 MILE REFLECTOR - RECORDED-CORRELATED

## 2. RANGE RESOLUTION

- A. RECEIVER RESPONSE MEASURED
- B. RESOLUTION CHECK OF RECEIVER WITH SYNTHETIC TARGETS- 25 FT. - LIMITED BY FIBER OPTICS

## 3. AZIMUTH RESOLUTION

- A. SYNTHETIC HOLOGRAMS GENERATED-RECORDED- CORRELATED
- FOR F101 CONDITIONS - SHARPENING RATIO OF 100/1  $\approx$  10 FT.

## 4. MISCELLANEOUS

- A. INVESTIGATED PULSE OVERTHROW - CORRECTED BY EXTENDING RECEIVER RESPONSE
- B. INVESTIGATED BEST RECORDER - FILM OPERATING POINT - 30% TRANSMISSION
- C. DYNAMIC RANGE OF RECEIVER-RECORDER- FILM COMBINATION > 20 db
- D. AFFECT OF LIMITING TO INCREASE DYNAMIC RANGE:

JF - NO CLUTTER  
 VIDEO - BAD HARMONICS

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ENVIRONMENTAL TEST

1. RADIO INTERFERENCE (SYSTEM) .... NO SUSCEPTIBILITY  
 .... MINOR RADIATION

2. EXPLOSION (SYSTEM) ✓

3. VIBRATION

RECEIVER ✓  
 SYNCHRONIZER ✓  
 NAV. TIE-IN ✓  
 POWER SUPPLY ✓  
 MODULATOR ✓  
 DUPLEX. DRIVER ✓  
 RESONANT RING — MTG BRACKET FAILED, CORRECTED. RECHECK  
 TWT NOISE FIGURE DETERIORATED.  
 RECORDER MOVEMENT OF LENS. MIRROR ✓

## SPECIAL INVESTIGATION

10, 20 ~ FROM POD  
 120, 160 ~ FROM ENGINE

4. CRASH SAFETY (SYSTEM) PLANNED  
 5. TEMP. ALTITUDE (SYSTEM) PLANNED

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**SECRET**FLIGHT TEST

## 1. FLIGHT S-II

LOC: ANNAPOLIS - SOUTH RIVER  
 ALT: 20,000 FT.  
 PWR: 0.06 MEG WATTS  
 PULSE: 10.0 NANOSEC

ESTIM. EFFECTIVE RESOL: [REDACTED] FT

## 2. MODIFICATIONS TO F-101 INSTALLATION

- A. LENS OPTICS RECORDER IN PLACE OF FIBER OPTICS
- B. TRANSMITTER RESONANT RING LENGTHENED - 10 TO 20 NANOSEC
- C. AUTOMATIC STABILIZATION OF ANTENNA BY DFT

## 3. FLIGHT S-33

LOC: ANNAPOLIS - SOUTH RIVER  
 ALT: 20,000 FT.  
 PWR: 0.11 MEG WATTS  
 PULSE: 20 NANOSEC

TARGETS: LEE AIRPORT..... GRASS STRIP. AMONG GRASS

SO. RIVER BRIDGE..... RE-INFORCED CONCRETE - 30 FT. WIDE

RIVA BRIDGE..... RE-INFORCED CONCRETE - 30 FT. WIDE

STEPNEY'S LANE..... MACADAM 30FT, CLEARING 45 FT.

BOAT PIERS..... WOOD - 5 AND 6 FT. WIDE

ESTIM. EFFECTIVE RESOL: [REDACTED] FT

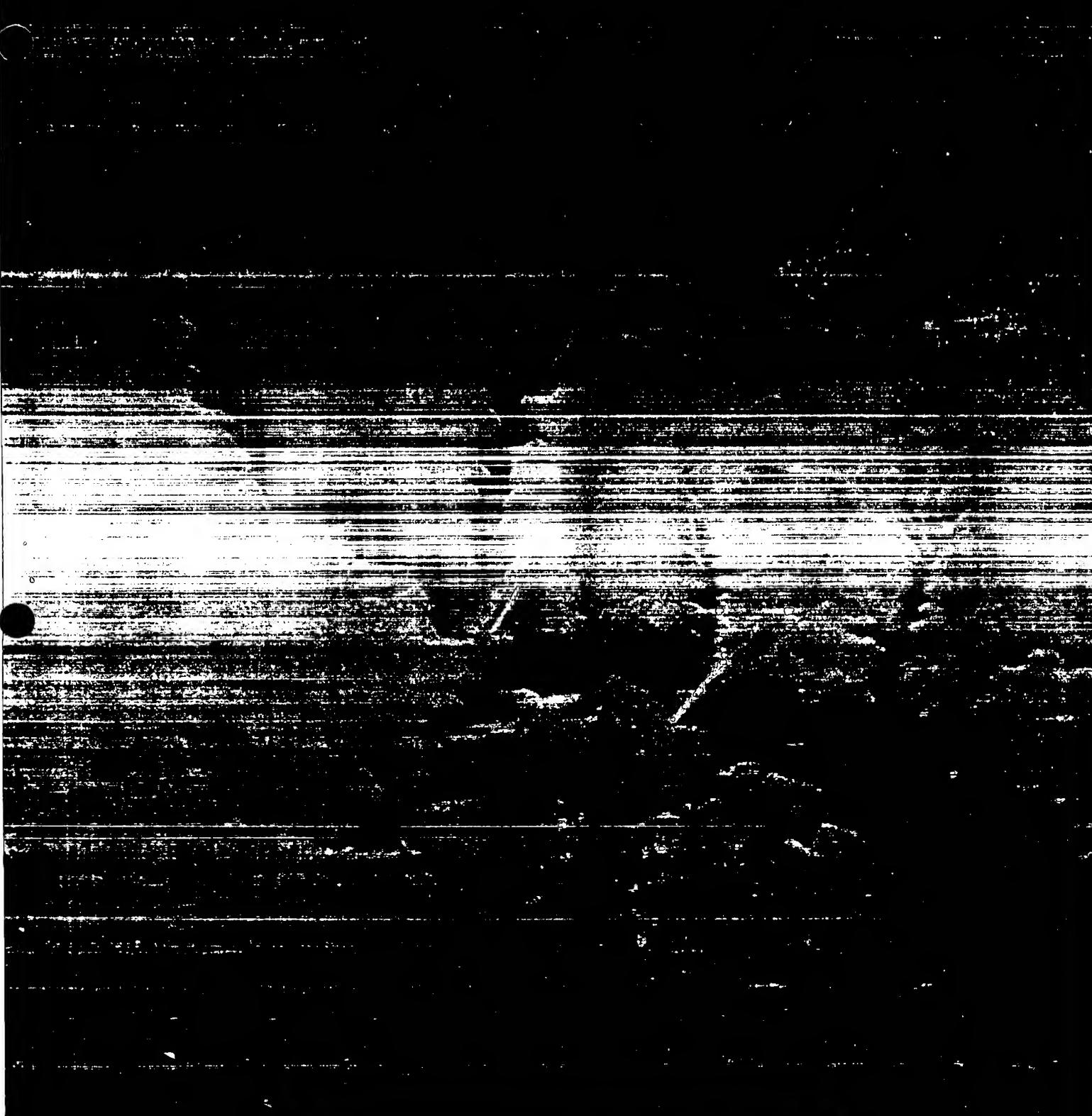
## 4. MODIFICATIONS TO F-101 INSTALLATION

- A. MOTION COMPENSATION SYSTEM
- B. GROUND SPEED SIGNAL FOR RECORDER
- C. IF LIMITING

## 5. MEASURED RANGE FLIGHTS

- A. CAMP CAMPBELL
- B. WILCOX LAKE

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Correlated Map Test Flight S-11.



Correlated Map Test Flight S-33.

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## TARGET DESCRIPTION

1- LEE AIRPORT STRIP

GRASS RUNWAY  
GRASS SURROUNDING

2- SOUTH RIVER BRIDGE

RE-INFORCED CONCRETE,  
30FT. WIDE

3- RIVA BRIDGE

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RE-INFORCED CONCRETE,

4- STEPNEYS LANE



MACADAM ROAD // CLEARING  
30 FT. WIDE // APPROX. 45 FT. WIDE

5- BOAT PIERS

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**SECRET**Correlated DataSouth River Area

	<u>S-33 Print or Film</u>	<u>S-11 Print</u>
1. airport runway	50 mils (160')	not visible
2. lower bridge	10 mils (32')	50 mils (160')
3. upper bridge	15 mils (50')	50 mils (160')
4. macadam road	10 mils (32')	off of picture
5. piers	7-10 mils (22'-32')	not visible
minimum size point target	7 mils (22')	15 mils (50')

Annapolis Area

academy object	15 mils (50')	25 mils (80')
Annapolis Bridge	7 mils (22')	not visible
Annapolis Bridge	10 mils (32')	25 mils (80')
boat dock objects	15 mils (50')	25 mils (80')
object on bay hook	10 mils (32')	25 mils (80')
minimum size point target	7 mils (22')	15 mils (50')

Scale Calculations

Scale 9" = 127 usec slant = 60,000' slant

Assume 1 mile dead slant range, so total slant range = 60,000 - 6,000

9" = 57,000-1/2 (because only correlate 1/2 of data film)

$$1 \text{ mil} = 6.5-1/2 = 3.2'$$

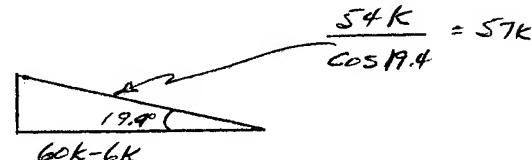
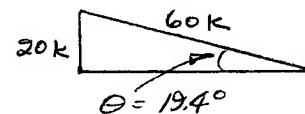
$$7 \text{ mils} = 45-1/2 = 22'$$

$$10 \text{ mils} = 65-1/2 = 32'$$

$$15 \text{ mils} = 100-1/2 = 50'$$

$$25 \text{ mils} = 160-1/2 = 80'$$

$$50 \text{ mils} = 320-1/2 = 160'$$

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**ACCESSORY MATERIAL AND SERVICE**

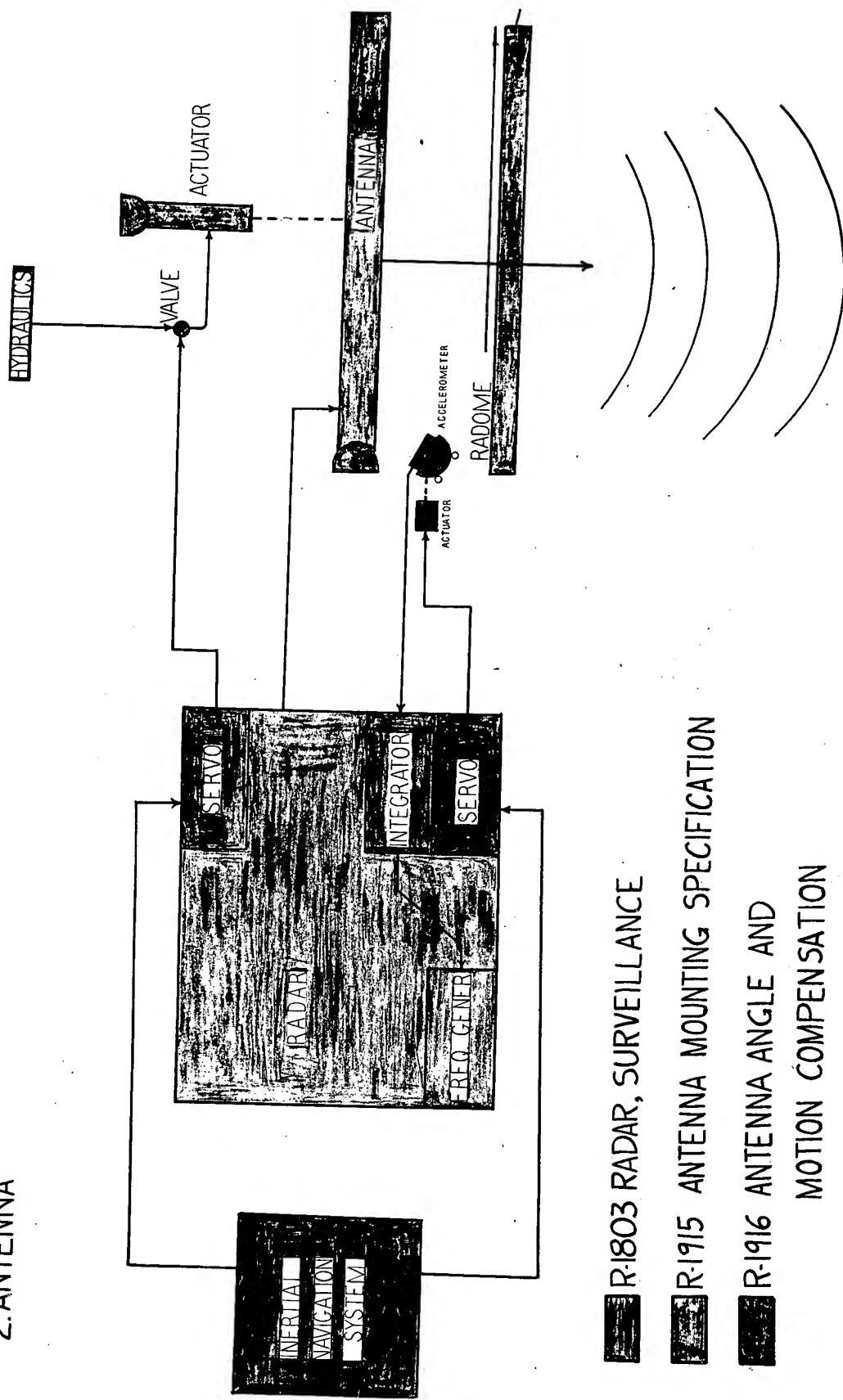
1. FIELD SPARES  
REVIEWING-CHANGING IN LINE WITH RADAR
2. FIELD TEST EQUIPMENT  
MODIFYING IN LINE WITH RADAR CHANGES
3. FIELD SERVICE  
ENGINEERS WORKING WITH DESIGN GROUP

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INSTALLATION

1. RADAR ASSEMBLY
2. ANTENNA



R-1803 RADAR, SURVEILLANCE

R-1915 ANTENNA MOUNTING SPECIFICATION

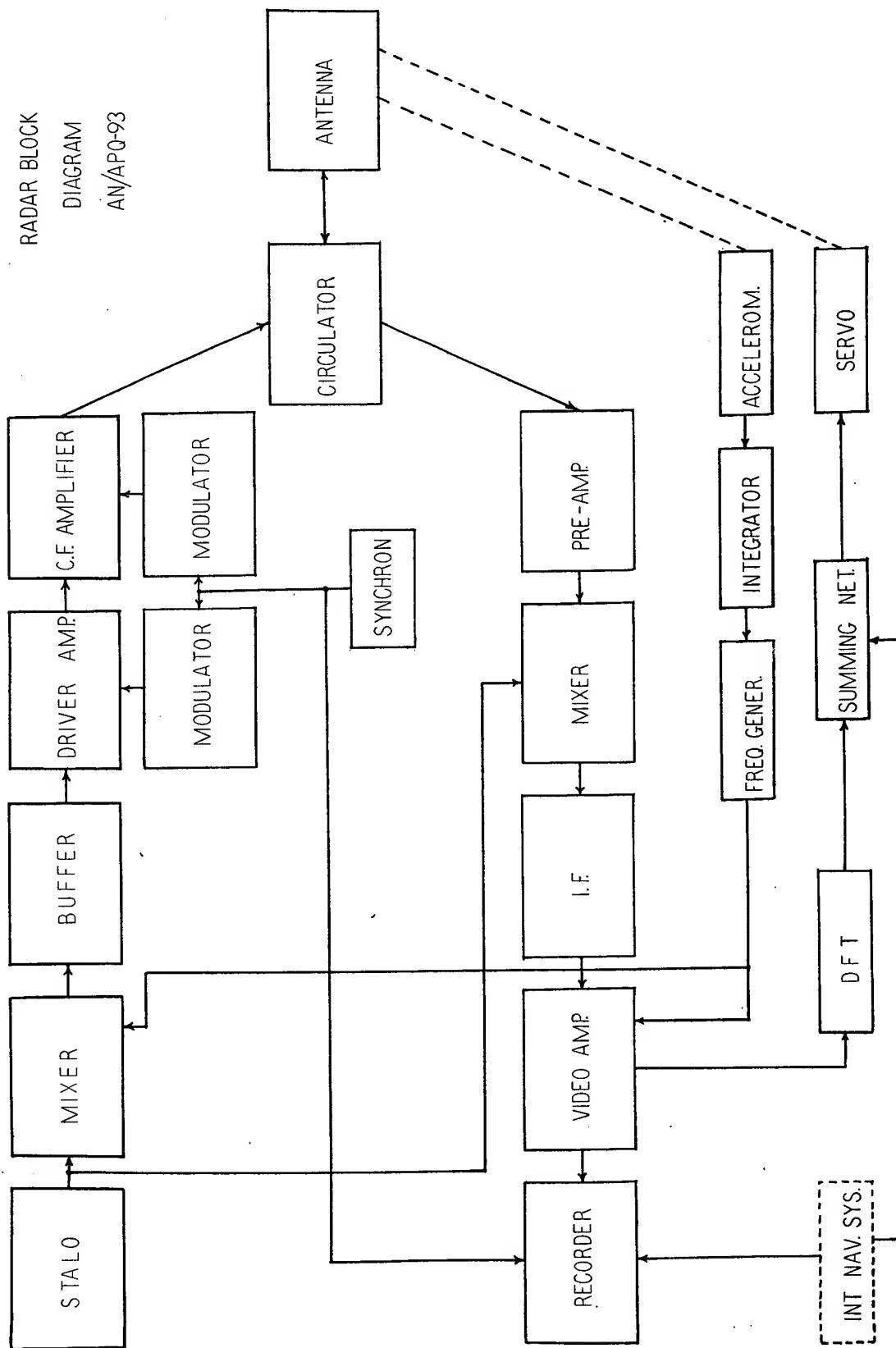
R-1916 ANTENNA ANGLE AND  
MOTION COMPENSATION

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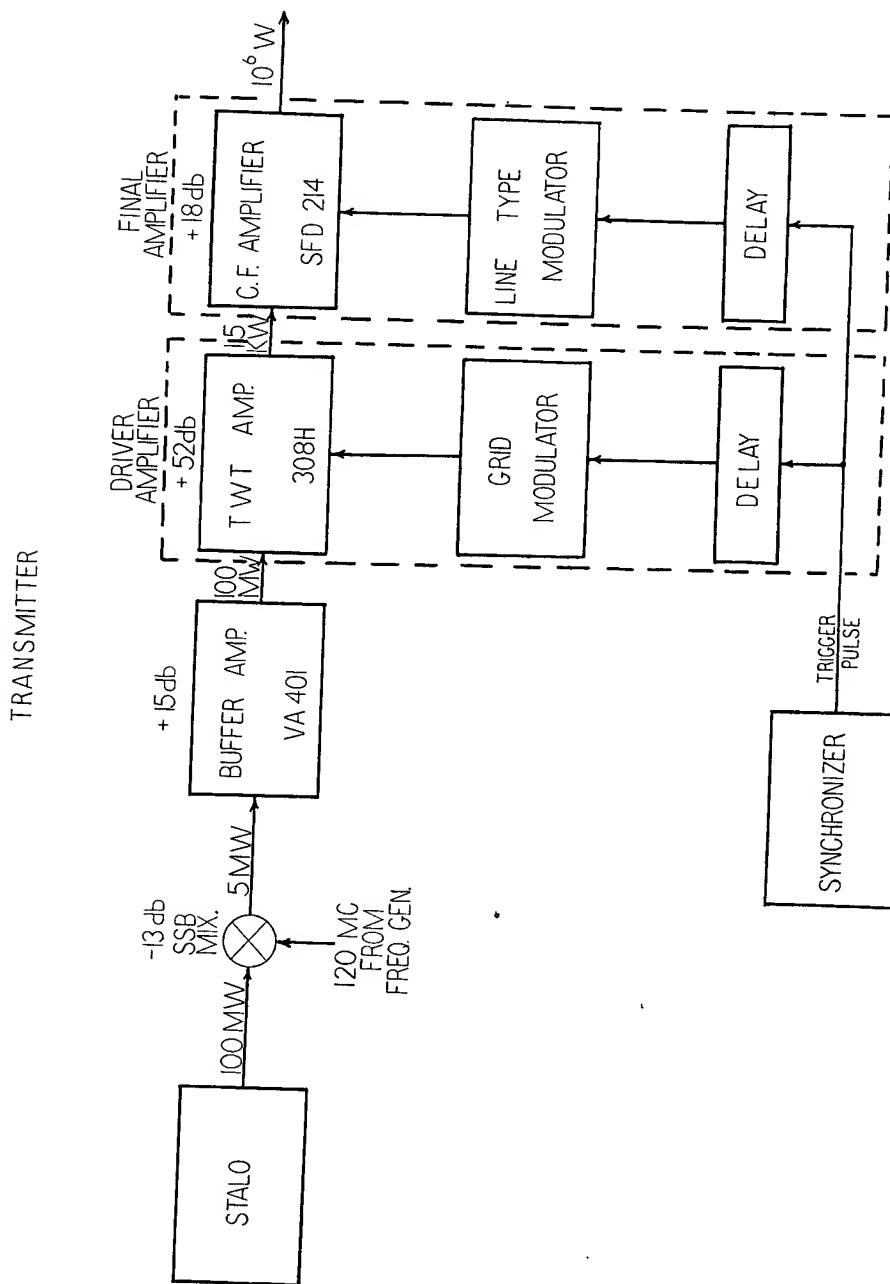
RADAR BLOCK DIAGRAM AN/APQ-93

DAR BLOCK  
DIAGRAM  
AN/APQ-93



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## RADAR PARAMETERS

## TRANSMITTER

FREQUENCY 2400 Mc  
 PEAK POWER 10<sup>6</sup> WATTS  
 PULSE WIDTH 30 x 10<sup>-9</sup> SEC.  
 PRF 3927  
 AVERAGE POWER 118 WATTS

## ANTENNA

FREQUENCY 9400 Mc  
 GAIN 31.5 dB  
 $A_E$  BEAMWIDTH 0.75 DEG.  
 $E_L$  BEAMWIDTH 20 DEG.  
 $E_L$  PATTERN  $C_{SL}^2 \cos^{1/2}$   
 $A_E$  SIDELOBE -14 dB  
 $E_L$  SIDELOBE -15 dB  
 $E_L$  IMAGE PATTERN -15 dB  
 VSWR 1.3  
 RADOME LOSS (ONE WAY) 1.75 dB

## RECEIVER

NOISE FIGURE (TWT FREND) 7.5 dB  
 DUPLEXER & LINE LOSSES 2.1 dB  
 CIRCULATOR - 0.25 dB (ONE WAY)  
 TWT PROTECTOR - 0.4 dB  
 WAVEGUIDE - 0.65 dB (ONE WAY)

STALO FREQUENCY 9280 Mc  
 I-F 120 Mc  
 1-F AMP BANDWIDTH 60 Mc  
 VIDEO AMP BANDWIDTH 47 Mc  
 IMAGE FILTER BANDWIDTH 70 Mc  
 IMAGE REJECTION 400 cps  
 COHO REF. OFFSET FREQ. 400 cps

## RECORDED

film SPEED 2.0"/SEC NOM.  
 CONTROL RANGE  $\pm 10\%$   
 CONTROL ACCURACY 0.1%  
 FILM CAPACITY 250' X 9.5"  
 CRT SPOT SIZE 0.0005"  
 SWEEP SPEED 1.02 Mc/30 x 10<sup>-9</sup> SEC  
 TRACK FREQ. 900 cps (max.)

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SYSTEM	WEIGHT
TRANSMITTER	210 *
RECEIVER	27
TWT PREAMP	11
RECORDER	175 *
VIDEO AMPLIFIER	3
SYNCHRONIZER	25
Nav - TIE - IN	20 *
POWER SUPPLY	70
CONTROL PANEL	2
ANTENNA	140 *
TOTAL	683
	TOTAL WEIGHT - 779

\* ESTIMATED WEIGHT

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